PRINCIPLES and MODERN APPLICATIONS of MASS TRANSFER OPERATIONS

Jaime Benitez

ftp:// SITE AVAILABLE

Exhibit DD

PRINCIPLES AND MODERN APPLICATIONS OF MASS TRANSFER OPERATIONS

Jaime Benitez

WILEY-INTERSCIENCE
A JOHN WILEY & SONS, INC., PUBLICATION

This text is printed on acid-free paper. ♾

For ordering and customer service, call 1-800-CALL-WILEY.

Library of Congress Cataloging-in-Publication Data:

Library of Congress Cataloging-in-Publication Data is available.
ISBN 0-471-20344-0

Printed in the United States of America.

10 9 8 7 6 5

tion, is the separa-
:r insoluble liquid.
nselves differently
eved. This can be
the manner of gas

on and some of its
on or oxidation of
n all three cases, a
l acetic acid (99.8
: need to vaporize
:ordingly, an alter-
l.
quid such as ethyl
ter phase. Since at
:nt, they will settle
: now the ratio of
l solution and also
of separation will
:an be carried out
:an be repeatedly
r we can arrange a
ne sort of counter-
volved. The use of

There are some other applications of liquid–liquid extraction where it seems uniquely qualified as a separation technique. Many pharmaceutical products (e. g., penicillin) are produced in mixtures so complex that only liquid–liquid extraction is a feasible separation process (Seader and Henley, 1998).

In all such operations, the solution which is to be extracted is called the *feed*, and the liquid with which it is contacted is the *solvent*. The solvent-rich product of the operation is called the *extract*, and the residual liquid from which solute has been removed is the *raffinate* (Treybal, 1980).

7.2 LIQUID EQUILIBRIA

Your objectives in studying this section are to be able to:

1. Plot extraction equilibrium data on equilateral- and right-triangular diagrams.
2. Explain the difference between type I and type II extraction equilibrium behavior.
3. Find the saturated extract, saturated raffinate, and conjugate lines on a right-triangular diagram.

Extraction involves the use of systems composed of at least three substances, and although for the most part the insoluble phases are chemically very different, generally all three components appear at least to some extent in both phases. A number of different phase diagrams and computational techniques have been devised to determine the equilibrium compositions in ternary mixtures. In what follows, A and B are pure, substantially insoluble liquids, and C is the distributed solvent. Mixtures to be separated by extraction are composed of A and C, and B is the extracting solvent.

Equilateral-triangular diagrams are extensively used in the chemical literature to graphically describe the concentrations in ternary systems. It is the property of an equilateral triangle that the sum of the perpendicular distances from any point within the triangle to the three sides equals the altitude of the triangle. We can, therefore, let the altitude represent 100 percent composition and the distances to the three sides the percentages or fractions of the three components (refer to Figure 7.1). Each apex of the triangle represents a pure component, as marked. The perpendicular distance from any point such as *K* to the base *AB* represents the percentage of C in the mixture at *K*, the distance to the base *AC* the percentage of B, and that to the base *CB* the percentage of A. Thus the composition at point *K* in Figure 7.1 is 40% A, 20% B, and 40% C.

Any point on a side of the triangle represents a binary mixture. Point *D*, for example, is a binary mixture containing 80% A, 20% B. All points on the line *DC* represent mixtures containing the same ratio of A to B and can be considered as mixtures originally at *D* to which C has been added.